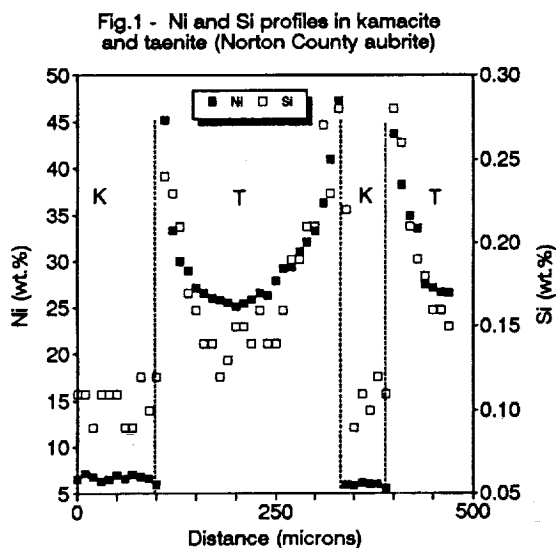


DISTRIBUTION OF SILICON BETWEEN KAMACITE AND TAENITE.

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Meteorites formed under highly reducing conditions can incorporate substantial amounts of Si in solid solution in their metallic phases. In enstatite meteorites, reduced Si appears in schreibersite, perryite and, in variable amounts, in the kamacite, taenite and tetrataenite^[1]. Microprobe bulk analyses of Si in Fe,Ni particles of aubrites show a large variation from grain to grain (<0.02-1.4 wt.%); this large compositional range has been attributed to local equilibrium conditions in the specific T and/or fO₂ environments in which they formed^[1,2]. Si concentrations are homogeneous in the kamacite; in contrast, the Ni-rich phases (taenite and tetrataenite) show a characteristic Si profile. Concentrations of this element in tetrataenite are substantially higher than in the adjacent kamacite, and decrease smoothly towards the center of the taenite grain, matching very closely the M-shaped profile of Ni (Fig. 1). Other elements with similar distribution patterns are Ge^[3] and Cu^[4]. A satisfactory explanation for this behavior cannot be given in the absence of experimental data for the diffusion of Si between α and γ -Fe alloys. However, two end-member possibilities can be envisioned: the distribution of Si between kamacite and taenite may be controlled by (1) the crystallographic structure or (2) the chemical composition (i.e., Ni content) of the host phases. If the distribution is structurally controlled, the observed Si compositional profile would represent a higher affinity of this element for the structure of the high-Ni phases, rather than the kamacite. However, the addition of Si to the Fe (and Ge and Cu to their respective alloys) favors the formation of α -Fe, and not the γ phase, as interpreted from the sub-solidus phase equilibrium diagrams for the Fe-(Si,Ge,Cu) binary systems. This is in apparent disagreement with the observations that Si is concentrated in the taenite (γ) and tetrataenite (γ'). An additional problem to silicon distribution being controlled by structure arises from the fact that formation of tetrataenite occurs at low temperatures (~320 °C, 1 bar), at which appreciable diffusive equilibration may be difficult. On the other hand, the observed Si compositional profiles may denote a chemical effect and, consequently, the distribution of Si may depend on the Ni content of the kamacite and taenite.



According to this, silicon and nickel would diffuse together during the sub-solidus cooling history of the metal. The main problem to this interpretation is that, while in the taenite the Ni/Si ratio is fairly constant over a wide variety of Ni contents, the $C^{\gamma'}/C^{\alpha}$ ratio is three times larger for Ni than for Si. This would suggest lack of linearity in the Ni/Si variation. Therefore, caution should be taken in assuming that Si and P may have similar effects in the growth rate of the kamacite^[5,6] and, consequently, in the metallographic cooling rates of meteorites formed under reducing conditions. It should also be noted that germanium displays a very similar behavior^[3] to that of Si, and the same kind of problems can be considered for both elements. Research currently in progress will be addressing this question in a systematic manner, with the aim to find further constraints to this apparently puzzling behavior.

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